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(54) COPOLYMERES HEMOCOMPATIBLES, HYDROPHILES ET BACTERICIDES

(54) HEMOCOMPATIBLE AND BACTERIA-REPELLING HYDROPHILIC COPOLYMERS

(57)

Disclosed is a hemocompatible and bacterio-repellant hydrophilic water-swellable copolymer composed of repeating units derivable from (A) at least one monomer that contains a sulfate and/or sulfonate group, (B) at least one monomer that contains a carboxyl and/or carboxylate group, and (C) at least one cross-linking agent that is at least bifunctional. The copolymer is suitable for hygienic or medical applications.

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(54) **COPOLYMERES HEMOCOMPATIBLES, HYDROPHILES ET BACTERICIDES**

(54) **HEMOCOMPATIBLE AND BACTERIA-REPELLING HYDROPHILIC COPOLYMERS**

(57) Disclosed is a hemocompatible and bacterio-repellant hydrophilic water-swellable copolymer composed of repeating units derivable from (A) at least one monomer that contains a sulfate and/or sulfonate group, (B) at least one monomer that contains a carboxyl and/or carboxylate group, and (C) at least one cross-linking agent that is at least bifunctional. The copolymer is suitable for hygienic or medical applications.

Abstract

Disclosed is a hemocompatible and bacterio-repellant hydrophilic water-swellable copolymer composed of repeating units derivable from (A) at least one monomer that contains a sulfate and/or sulfonate group, (B) at least one monomer that contains a carboxyl and/or carboxylate group, and (C) at least one cross-linking agent that is at least bifunctional. The copolymer is suitable for hygienic or medical applications.

Hemocompatible and Bacterio-repellant Hydrophilic Copolymers

Field of the Invention

The present invention relates to hydrophilic copolymers that are hemocompatible (or hemophilic) and bacterio-repellant, optionally cellulostatic or promoting cellular proliferation, that are swellable and form hydrogels in an aqueous medium. The present invention also relates to a process for producing the copolymers, and use thereof.

Swellable polymers or copolymers (i.e., those that absorb a substantial amount of water) are used for many applications. One such example is for the so-called superabsorbers for infant diapers. For this purpose, the polymers are frequently provided with all sorts of process materials and additives that are intended to enhance their dermal compatibility, amongst other things. Other products for which swellable polymers are required are for wound dressings, sanitary napkins and tampons, and compresses.

Brief Description of the Drawings

Figures 1 to 4 show the results of swelling tests conducted with various swellable copolymers according to the present invention, which contain different amounts of cross-linking agents, in water or in a physiological solution of cooking salt.

Summary of the Invention

The present invention provides a hemo-compatible and bacterio-repellant hydrophilic, water-swellable copolymer having repeating units of (A) at least one monomer that contains a sulfate and/or sulfonate group, (B) at least one

monomer that contains a carboxyl and/or carboxylate group, and (C) at least one cross-linking agent that is at least bifunctional.

The present invention also provides a process for manufacturing the copolymer, and use of the copolymer.

Within the context of the present invention, a copolymer is hydrophilic and swellable if the water absorption established by the test described below amounts to at least 80 per cent. The copolymers according to the present invention may often absorb up to 100 times their own weight of water. The water absorption is reversible, even though reversibility is not a concern for many practical applications. The copolymers are extremely hemocompatible, and greatly extend blood-coagulation times. This effect is as long-lasting as the powerful bacterio-repellant effect. The particular conditions under which a copolymer is cellulostatic or promotes cellular proliferation will be described below. This combination of advantageous characteristics displayed by the copolymers according to the present invention is associated with good dermal and tissue compatibility, so that the copolymers according to the present invention are particularly suitable for medical applications.

Description of Preferred Embodiments of the Invention

The repeating units of the copolymers referred to above may originate directly from the cited monomers (A) and (B) and from the cross-linking agent (C). Alternatively, derivatives of these starting substances can be used, and they may be

converted into the cited repeating units after polymerisation. As an example, a sulfonic acid and/or carboxyl group may be converted into a sulfonate and/or carboxylate group subsequently. In addition, a carbonamide or nitrile group, as well as a carboxylic acid ester or sulfonic acid ester group can be converted into a carboxylate or sulfonate group by hydrolysis and, if necessary, by neutralisation.

Naturally, mixtures of different monomers (A) and (B) can be used in place of a single monomer (A) or a single monomer (B). The foregoing commentary on groups that can be converted into the cited physiologically acceptable salt groups will apply accordingly.

It is also possible to use only one monomer (A+B) that contains the cited, physiologically acceptable groups (or groups that can be transformed into these groups) in the same molecule in place of the two monomers (A) and (B).

The monomers (A) have a sulfate or sulfonate group that is important for the hemocompatibility and bacterio-repellant properties of the copolymers according to the present invention. They are mainly generally well known substances, and are readily available. They can be polymerized radically, and contain one or optionally two ethylene double bonds and one or optionally two sulfate and/or sulfonate groups with one equivalent of a physiologically acceptable cation, such as an alkali metal ion, in particular a sodium ion, as a counter-ion. In the same way, the monomers (B) are mainly well-known and readily available substances. They supply the carboxyl and/or carboxylate group that is similarly necessary for the

effects that have been cited, the latter once again with a physiologically acceptable cation, such as an alkali metal ion, in particular a sodium ion, as a counter-ion.

Examples of suitable monomers (A) and (B) are described by the following general formulas I and II:

Formula I: $(C_nH_{2n-q-x})(SO_3R^a)_x$ (A Monomers)

Formula II: $(C_nH_{2n-q-x})(COOR^b)_x$ (B Monomers)

wherein:

n stands, in each case independently, for an integer of from 2 to 6;

x stands, in each case independently, for 1 or 2;

q stands, in each case independently, for 0 or 2;

R^a stands for one equivalent of a cation, preferably a physiologically acceptable cation, such as a metal ion, in particular an alkali metal ion, and

R^b stands for -H or one equivalent of a cation, preferably a physiologically acceptable cation, such as a metal ion, in particular an alkali metal ion.

In accordance with the above definitions, the (C_nH_{2n-q-x}) radical stands, independently in each case, for a straight-chain or branched monovalent alkenyl radical (q=0, x=1) or an alka-dienyl radical (q=2, x=1) or a divalent alkenylene radical (q=0, x=2) or a divalent alkadienylene radical (q=2, x=2).

Monomers (A) and (B) derived from benzene, of the general

Formula III: $(C_6H_{6-b-c-d})B_bR^c{}_c(OH)_d$ (Monomers A or B)

can also be used. In this formula,

B stands, in each case independently, for a mono- or di-unsaturated straight-chain or branched radical of the formula $(C_nH_{2n-1-q-y})(SO_3R^a)_y$ or $(C_nH_{2n-1-q-y})(COOR^b)_y$, wherein R^a, R^b, n, and q are defined as before, and y stands, independently in each case, for 0, 1, or 2;

R^c stands, independently in each case, for C_{1-4}-alkyl, $-NH_2$, -COOH, $-SO_3H$, $-OSO_3H$, $-OPO(OH)_2$, $-PO(OH)_2$, $-OP(OH)_2$, $-OPO(O^-)OCH_2-CH_2-N^+(CH_3)_3$, $-PO(O^-)O-CH_2-CH_2-N^+(CH_3)_3$, $-OP(O)OCH_2-CH_2-N^+(CH_3)_3$ or a salt, preferably a physiologically acceptable salt, in particular an alkali salt, or an ester of the cited groups;

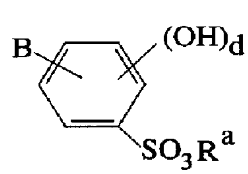
b stands for 1, 2, or 3;

c stands for 0, 1, 2, or 3; and

d stands for 0, 1, 2, or 3,

provided that b + c + d is at most 6, preferably no more than 4.

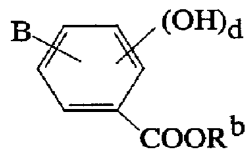
When R^C is a salt of $-SO_3H$ and c is 1, then the Formula III is represented by:



(III – A).

Preferably, d is 0, and y is 0.

When R^C is -COOH and c is 1, then the formula (III) is represented by:



(III – B)

Preferably, d is 0 and y is 0.

Examples of other suitable monomers (A) are sulfates of the Formula IV:

Formula IV: $(C_nH_{2n-q-x})(OSO_3R^a)_x$ (A monomers)

wherein R^a, n, q, and x are defined as before.

Examples of suitable monomers (A) are sodium allylsulfate, sodium allylsulfonate, sodium methallylsulfate, sodium vinyltoluene sulfonate, sodium vinylsulfonate, sodium 2-, 3-, or 4-vinylbenzenesulfonate (i.e., 2-, 3- or 4-styrene sulfonate), sodium 1-butene-4-sulfate and sodium 1-butene-2-sulfate. The following are specific examples of suitable monomers (B): acrylic acid, methacrylic acid, 4-vinylsalicylic acid, itaconic acid, vinylacetic acid, cinnamic acid, 4-vinylbenzoic acid, 2-vinylbenzoic acid, sorbic acid, caffeic acid, maleic acid, methylmaleic acid, crotonic acid, isocrotonic acid, fumaric acid, dimethylfumaric acid, methylfumaric acid, dihydroxymaleic acid, allylacetic acid, and the sodium salts for these acids. One monomer (A+B) that contains both the sulfonate and carboxylate groups is, for example, carboxylvinylbenzenesulfonate or a salt thereof, such as disodium 3-carboxylate-4-vinylbenzenesulfonate.

In the polymers according to the present invention, which are derived from monomers (A) and (B) of the general formulas

I to IV, the molar ratio of carboxyl and/or carboxylate groups to the sulfate and/or sulfonate groups in the coating can vary within very wide limits. Outstanding bacterio-repellant properties are displayed by gels in which this ratio is between 0.2 and 10. Bacterio-repellant and simultaneous cellular proliferation properties are well achieved when the ratio is 0.2 to 3, preferably 0.4 to 3, and in particular 0.4 to 2. In a remarkable way, the coated surfaces exhibit both bacterio-repellant and cellular proliferating properties when this particular molar ratio is 2 to 10, preferably 3 to 10, and in particular 3 to 5 . Within the context of the present invention, a coating is considered to promote cellular proliferation if the adhesion and proliferation of mammal cells is improved by the coating, or is less impaired by the coating as compared to the uncoated surface, or in any case is less impaired than the adhesion and proliferation of bacteria.

Cross-linking agent (C)

The cross-linking agents (C) are preferably radically polymerizable compounds containing two to four olefin double bonds. Cross-linking agents with two olefin double bonds form two-dimensional networks, whereas higher-functional cross-linking agents result in three-dimensional networks that do not swell as much, and form hydrogels with less water. For this reason, higher-functional cross-linking agents are best used in smaller molar quantities than the bifunctional cross-linking agents, so that the degree of cross-linking is not allowed to become too great (for this would reduce the ability

to absorb water). Naturally, two or more different cross-linking agents may be used, for example, a mixture of a bifunctional cross-linking agent and a trifunctional cross-linking agent. Because of the swellability (or the ability to absorb water) that is desired for the copolymers according to the present invention, the cross-linking agent is preferably hydrophilic, e.g., it should preferably contain a polyalkyleneoxide group.

Examples of suitable cross-linking agents are methylene bisacrylamide(MBAA), ethyleneglycol dimethacrylate(EGDMA), diethyleneglycol dimethacrylate, ethyleneglycol diacrylate(EGDA), diethyleneglycol diacrylate(DEGDA), polyethyleneglycol-1000 dimethacrylate, diethyleneglycol divinylether(DEGDV), polyethyleneglycol-300 divinylether, polyethyleneglycol-1500 divinylether, polyethyleneglycol-6000 divinylether, cyclohexane-1,4-dimethanol divinylether, 1,6-hexanediol divinylether, 1,6-hexanediol dimethacrylate, allyl cinnamate, glycerine trivinylether, glycerine-12EO trivinylether, trimethylolpropane triacrylate, trimethylolpropane trimethacrylate, trimethylolpropane trivinylether, pentaerythritol tetraacrylate, and pentaerythritol triallylether.

The degree of cross-linking is determined by the size of the molar amount of the cross-linking agent (C) to the sum of the molar parts of (A) and (B) monomers and, optionally, (D), and of the cross-linking agent (C). When a bifunctional cross-linking agent is used, this amount lies, in general, in the range from 1 to 40%. When the (average) functionality of

the cross- linking agent is higher, for example, 3 or 5, the amount of the cross-linking agent is preferably 0.01 to 10 molar%.

Additional monomers (D)

The copolymers according to the present invention may contain repeating units that are derived exclusively from the monomers (A) and (B) and the cross-linking agent (C), or contain other repeating units that are originated from other vinyl monomers (D) that modify the properties of the copolymers according to the present invention to the desired extent. Thus, repeating units that are originated from hydrophylic monomers, particularly those being non-ionic and having a hydroxyl group, such as 2-hydroxyethyl methacrylate(HEMA), diethyleneglycol monacrylate, 1,4-butanediol monoacrylate or vinyl monosaccharides, or from other property-modifying monomers can be present. Hydrophilic vinyl monomers (D) are used especially if, as an exception, the monomers (A) and (B) and the cross-linking agent (C) generate a copylymer that is not sufficiently hydrophilic and swellable in the sense of the present invention. When those other repeating units that are originated from the monomers (D) are present in the copolymer, generally the quantity of these may be up to about 40 molar%, in particular up to 30 molar%, relative to the sum of the repeating units that are originated from the monomers (A) and (B) and the cross-linking agent (C).

Production of the copolymers according to the present invention

In order to produce the copolymers, the monomers (A) and (B) (or alternatively the monomer (A+B)), the cross-linking agent (C) and, optionally the other monomers (D) are radically copolymerized in an aqueous medium, in a usual manner. As initiators, it is desirable to use peroxides that can be used for aqueous systems, e.g., persulfates such as potassium peroxide disulfate; peresters; hydroperoxides, such as tert.-butylhydroperoxide; and azo compounds such as azo-isobutyronitrile. The initiators are best used in quantities of 0.01 to 1 molar%, relative to the quantities of the monomers. All the starting substances may be changed at once or, it is also possible for example, to first copolymerize the monomers (A) and (B), and optionally the monomers (D), and then add the cross-linking agent (C) subsequently, if necessary with an additional initiator. Polymerization proceeds rapidly in the temperature range from 40 to 100°C. Depending on the degree of cross-linking, the reaction mixture is a more or less viscous, clear solution, or already a gel. The copolymer may be isolated by putting the reaction mixture into a solvent which is miscible with water, but in which the copolymer is insoluble, e.g., in ethanol. Using methanol, soluble, low-molecular fractions, such as monomers or initiator components, may be washed out of the copolymer that has been filtered off. The product, for the most part water-free, can be obtained by careful drying, for example, at 60°C in a vacuum.

The copolymer according to the present invention is usually a solid that is sometimes tacky but can be broken up in a

mortar. Water absorption and water excretion are reversable. The water absorption can be determined by differential weighing. Most of the copolymers can absorb up to 200 times their own weight of water, depending on the degree to which the monomers and the cross-linking agent are hydrophilic, and the amount of cross-linking.

Use of the copolymers

The copolymers according to the present invention can be used for producing products in which hemocompatibility and/or bacterio-repellant properties are important. Both of these properties are important for medical applications. The copolymer is suitable, for example, for producing articles, such as compresses and wound dressings. It absorbs the watery liquid that escapes from wounds, and has a simultaneous disinfecting action. Another use is as substrate for implant active substances. In addition, the hydrogel of the copolymer can serve as a water reservoir for plants and cut flowers; when used for this purpose, because of its bacterio-repellant properties, it also prolongs the life of cut flowers. It can also be used for feminine hygiene products such as sanitary napkins and tampons.

The examples that follow explain the present invention in greater detail without, however, restricting it to such areas of application.

Examples 1 to 15

General instruction

206 g (1 mol) sodium 4-vinylbenzenesulfonate (i.e., sodium styrenesulfonate: NaSS), 116 g (1 mol) maleic acid (MS), 2

litres water, and the quantities of cross-linking agent set out in the table were placed in a 3-litre round flask. 1 molar% (= 0.02 mol) $K_2S_2O_8$ was added, and the mixture was heated to 60°C whilst being stirred. Polymerization was terminated after 4 hours. The mixture was allowed to cool to room temperature and the reaction mixture was placed in 10 litres ethanol. The precipitated copolymer was decanted off, and dried to constant weight by heating to 60°C.

The examples of the following series of tests show possible variants for the cross-linking agent under otherwise equal conditions.

Table

Ex.	Cross-linking agent	Compatibility at mol-% cross-linking agent
1	Methylene bisacrylamide (MBBA)	1.4
2	Ethyleneglycol dimethacrylate	5
3	Diethyleneglycol dimethacrylate	20
4	Polyethyleneglycol-1000 dimethacrylate	10
5	Diethyleneglycol divinylether	10
6	Glycerine-12EO trivinylether	1
7	Pentaerythrite-64EO tetravinylether	10
8	Pentaerythritol tetraacrylate	1.4
9	Pentaerythritol triallylether	1.4
10	Polyethyleneglycol-300 divinylether	10
11	Polyethyleneglycol-1500 divinylether	10
12	Polyethyleneglycol-6000 divinylether	10
13	1,6-hexanediol divinylether	1
14	Cyclohexane-1,4-dimethanol divinylether	1
15	Allyl cinnamate	1

A cross-linking agent is regarded as compatible in the quantity cited if it results in a clear, homogenous reaction mixture. The values cited are not limiting values, but rather quantities atibility is still achieved.

Determination of water absorption

200 mg of dried gel was sealed into a coated teabag; the bag was then suspended for a specific period of time in the aqueous medium (distilled water or physiological sodium chloride solution). The bag was then allowed to drip drain for 10 minutes, and then weighed. The water absorption was determined by the formula:

$$\text{Water absorption in } \% = \frac{\text{wet gel} - \text{dry gel}}{\text{dry gel}} \times 100$$

Figures 1 and 2 show water absorption in deionized water and physiological saline (i.e., sodium chloride solution) as a function of the time for the maleic acid (MS), sodium 4-styrenesulfonate (NaSS) (molar ratio 1:1) and methylene bisacrylamide (MBAA) system with increasing quantities of the latter. Figures 3 and 4 show the corresponding results with a similar system, in which MBAA was replaced by polyethyleneglycol-1000 dimethacrylate (PEG-1000-DMA). It can be seen that water absorption in physiological saline is notably less than in water, at least with the weakly cross linked gels, although it still remains above 90%.

Measurement of bacterial adhesion

A sample of the gel was allowed to swell for one hour in a sterile PBS buffer solution, and then agitated for 2 hours at 37°C with a suspension of *Klesbiella pneumoniae*. Loosely adhering bacteria were removed by five repeated washings with PBS buffer solution. The adenosine triphosphate (ATP)bacterial content was extracted in the usual way from the bacteria still adhering to the gel and then measured bioluminometrically with a commercially available test combination (Boehringer Mannheim GmbH). The number of light pulses measured is proportional to the bacterial adhesion.

Bacterial adhesion was measured on a gel consisting of 40 molar% MS, 40 molar% NaSS, and 20 molar% MBAA and, for

comparison, on material with a similar surface area, namely, expanded polystyrene (EPS). Adhesion on the gel was only 5% of the adhesion on the EPS.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A hemato-compatible and bacterio-repellant hydrophilic water-swellable copolymer having repeating units of:

[i] (A) at least one monomer that contains at least one of sulfate and sulfonate groups, (B) at least one monomer that contains at least one of carboxyl and carboxylate groups and (C) at least one cross-linking agent that is at least bifunctional, or

[ii] (A-B) at least one monomer that contains at least one of sulfate and sulfonate groups and at least one of carboxyl and carboxylate groups and (C) at least one cross-linking agent that is at least bifunctional.

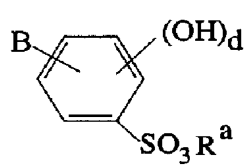
2. The copolymer as defined in claim 1, which has repeating units of the monomers (A) and (B) and the cross-linking agent (C).

3. The copolymer as defined in claim 2, wherein:

the monomer (A) is represented by the formula:

$(C_nH_2n-q-x)(SO_3R^a)_x$ (I)

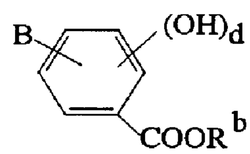
$(CnH_{2n-q-x})(OSO_3R^a)_x$ (IV) or



(III – A); and

the monomer (B) is represented by the formula:

$(C_nH_{2n-q-x})(COOR^b)_x$ (II) or



(III − B),

wherein:

$\underline{n}$ is an integer of 2 to 6;

$\underline{x}$ is 1 or 2;

$\underline{q}$ is 0 or 2;

R^a is one equivalent of a physiologically acceptable cation;

R^b is hydrogen or one equivalent of a physiologically acceptable cation;

B is a mono- or di-unsaturated strait-chain or branched radical of the formula $(C_nH_{2n-1-q-y})(SO_3R^a)y$ or $(CnH_{2n-1-q-y})$-$(COOR^b)y$;

$\underline{d}$ is 0, 1, 2 or 3; and

$\underline{y}$ is 0, 1 or 2.

4. The copolymer as defined in claim 2, wherein the monomer (A) is at least one member selected from the group consisting of sodium allylsulfate, sodium allylsulfonate, sodium methallylsulfate, sodium vinyltoluenesulfonate, sodium vinylsulfonate, sodium 2-, 3- or 4-vinylbenzenesulfonate, sodium 1-butene-4-sulfate and sodium 1-butene-2-sulfate.

5. The copolymer as defined in claim 2, wherein the monomer (A) is sodium 4-styrenesulfonate, sodium vinylsulfonate or sodium methallylsulfonate.

6. The copolymer as defined in claim 2, 4 or 5, wherein the monomer (B) is at least one member selected from the group consisting of acrylic acid, methacrylic acid, 4-vinylsalicylic acid, itaconic acid, vinylacetic acid, cinnamic acid, 4-vinyl benzoic acid, 2-vinylbenzoic acid, sorbic acid, coffeic acid, maleic acid, methylmaleic acid, crotonic acid, isocrotonic acid, fumaric acid, dimethylfumaric acid, methylfumaric acid, dihydroxymaleic acid, allylacetic acid and sodium salts of these acids.

7. The copolymer as defined in claim 6, wherein the monomer (B) is maleic acid, acrylic acid, methacrylic acid, 4-vinylbenzoic acid, or a sodium salt of these acids.

8. The copolymer as defined in claim 2, wherein the monomer (A) is represented by the formula (I) or (IV) and the monomer (B) is represented by the formula (II):

$$(C_nH_{2n-q-x})\ (SO_3R^a)_x \qquad (I)$$

$$(C_nH_{2n-q-x})\ (COOR^b)_x \qquad (II)$$

$$(C_nH_{2n-q-x})\ (OSO_3R^a)_x \qquad (IV)$$

(wherein:

<u>n</u> stands, in each case independently, for an integer of from 2 to 6;

x stands, in each case independently, for 1 or 2;

q stands, in each case independently, for 0 or 2;

R^a stands for one equivalent of a metal ion; and

R^b stands for -H or one equivalent of a metal ion); or the monomer (A) or the monomer (B) is represented by the formula:

$$(C_6H_{6-b-c-d})B_bR^c{}_c(OH)_d \qquad (III)$$

(wherein:

B stands, in each case independently, for a mono- or di-unsaturated straight-chain or branched radical of the formula $(C_nH_{2n-1-q-y})(SO_3R^a)_y$ or $(C_nH_{2n-1-q-y})(COOR^b)_y$, wherein R^a, R^b, n, and q are as defined above, and y stands, independently in each case, for 0, 1, or 2;

R^c stands, independently in each case, for C_{1-4}-alkyl, $-NH_2$, -COOH, $-SO_3H$, $-OSO_3H$, $-OPO(OH)_2$, $-PO(OH)_2$, $-OP(OH)_2$, $-OPO(O)OCH_2-CH_2-N+(CH_3)_3$, $-PO(O^-)O-CH_2-N+(CH_3)_3$, $-OP(O)OCH_2-CH_2-N+(CH_3)_3$ or a salt or an ester of the cited groups;

b stands for 1, 2, or 3;

c stands for 0, 1, 2, or 3; and

d stands for 0, 1, 2, or 3,

provided that the sum of b + c + d is no more than 6 and that at least one of a salt of $-SO_3H$ or $-OSO_3H$ and -COOH is contained).

9. The copolymer as defined in any one of claims 1 to 8, wherein the cross-linking agent is a radically polymerizable compound having 2 to 4 olefin double bonds.

10. The copolymer as defined in claim 9, wherein the

cross-linking agent has 2 olefin double bonds.

11. The copolymer as defined in claim 9 or 10, wherein the cross-linking agent contains a polyalkyleneoxide group.

12. The copolymer as defined in any one of the claims 1 to 8, wherein the cross-linking agent is methylene-bisacrylamide, ethyl-eneglycol dimethacrylate, diethyleneglycol dimethacrylate, polyethyleneglycol-1000 dimethacrylate, diethyleneglycol divinylether, glycerine-12EO trivinylether, pentaerythritol-64EO tetravinylether, pentaerythritol tetraacrylate, pentaerythritol triallylether, polyethyleneglycol-300 divinylether, polyethylene-glycol-1500 divinylether, polyethyleneglycol-6000 divinylether, 1,6-hexanediol divinylether, cyclohexane-1,4-dimethanol divinylether or allyl cinnamate.

13. The copolymer as defined in any one of the claims 1 to 12, which has a molar ratio of the carboxyl and/or carboxylate group to the sulfate and/or sulfonate group is 0.2 to 10.

14. The copolymer as defined in any one of claims 1 to 13, wherein the repeating units also contain those of (D) at least one other vinyl monomer in an amount of up to 40 molar% based on the total repeating units, the other vinyl monomer being non-ionic and hydrophilic and having a hydroxyl group.

15. The copolymer as defined in any one of claims 1 to 13, which is composed solely of the repeating units of the monomers (A) and (B) and the cross-linking agent (C) or the repeating units of the monomer (A+B) and the cross-linking agent (C).

16. The copolymer as defined in any one of claims 1 to 15, wherein the cross-linking agent is contained in an amount of 1 to 40 molar% when the cross-linking agent is bifunctional or 0.01 to 10 molar% when the cross-linking agent has an average functionality higher than 2 up to 5, each based on the total amount of the repeating units.

17. A process for manufacturing the copolymer as defined in any one of claims 1 to 16, which comprises:

radical initiated copolymerization of the monomers (A) and (B), the cross-linking agent (C), and optionally the other monomer (D) or the monomer (A+B), the cross-linking agent (C) and optionally the other monomer (D) in an aqueous medium.

18. A process as defined in claim 10, wherein the polymerization is conducted at 40 to 100°C, using a peroxy compound as an initiator.

19. An article which is made of the copolymer as defined in any one of the claims 1 to 16 and which is adapted to be used for a hygienic or medical purpose.

20. An article as defined in claim 19, which is a wound dressing.

21. An article as defined in claim 19, which is an implant active substance.

22. A reservoir for plants or cut flowers made of the copolymer as defined in any one of claims 1 to 16 in the form of a hydrogel.

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PATENT AGENTS

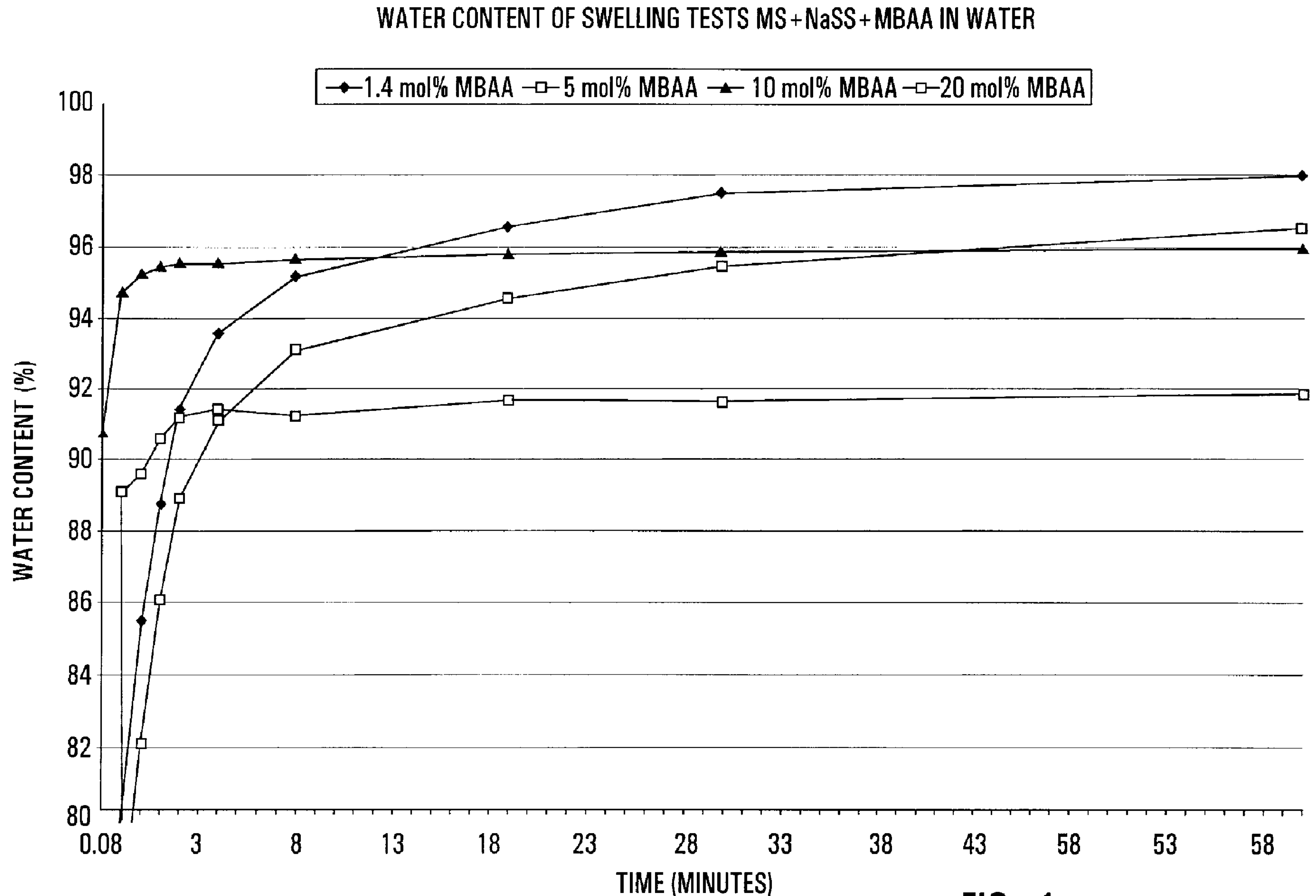
WATER CONTENT OF SWELLING TESTS MS+NaSS+MBAA IN WATER
1.4 mol% MBAA
5 mol% MBAA
10 mol% MBAA
20 mol% MBAA
WATER CONTENT (%)
100
98
96
94
92
90
88
86
84
82
80
0.08
3
8
13
18
23
28
33
38
43
58
53
58
TIME (MINUTES)

FIG. 1

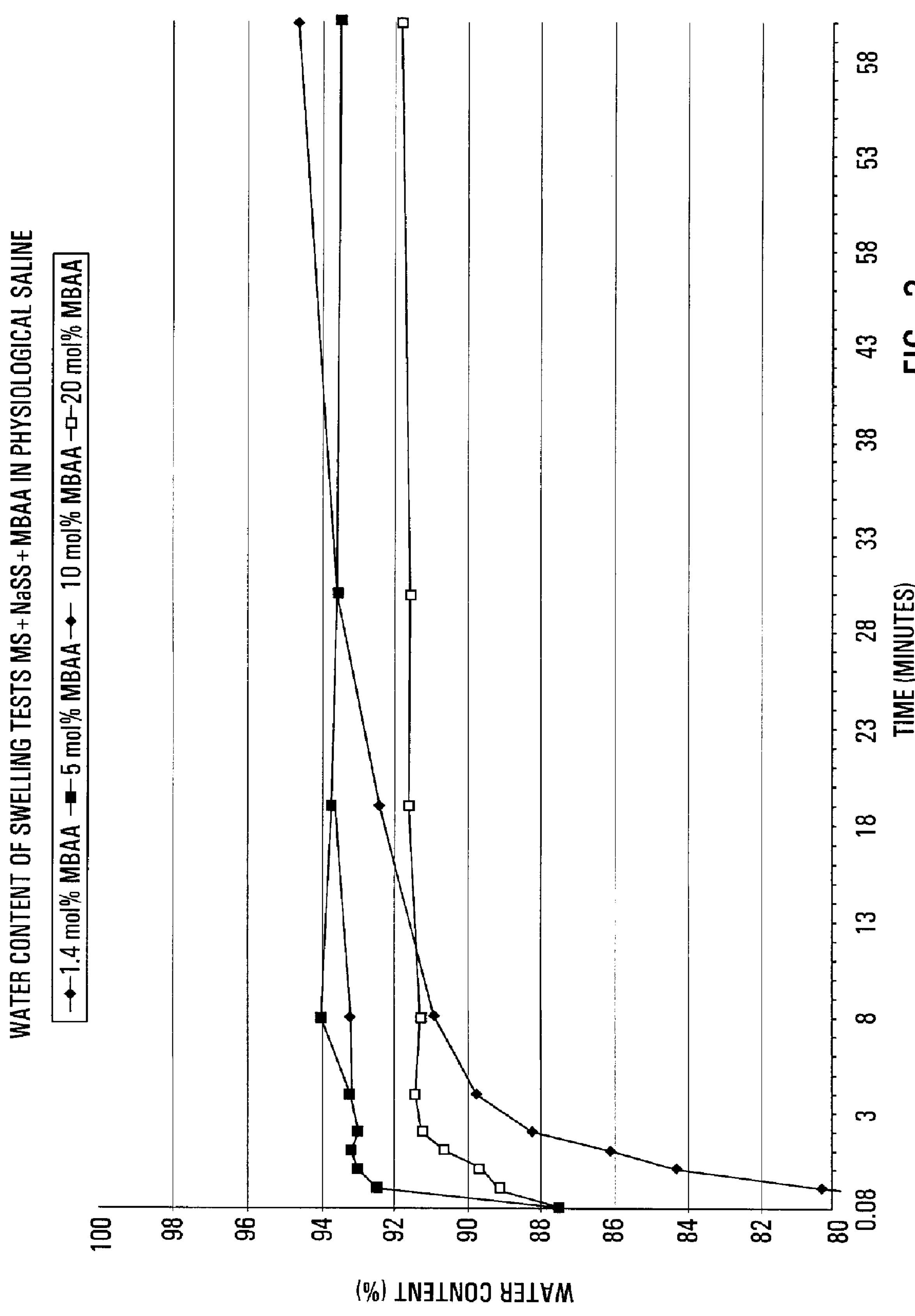
WATER CONTENT OF SWELLING TESTS MS+NaSS+MBAA IN PHYSIOLOGICAL SALINE
1.4 mol% MBAA
5 mol% MBAA
10 mol% MBAA
20 mol% MBAA
WATER CONTENT (%)
100
98
96
94
92
90
88
86
84
82
80
0.08
3
8
13
18
23
28
33
38
43
58
53
58
TIME (MINUTES)

FIG. 2

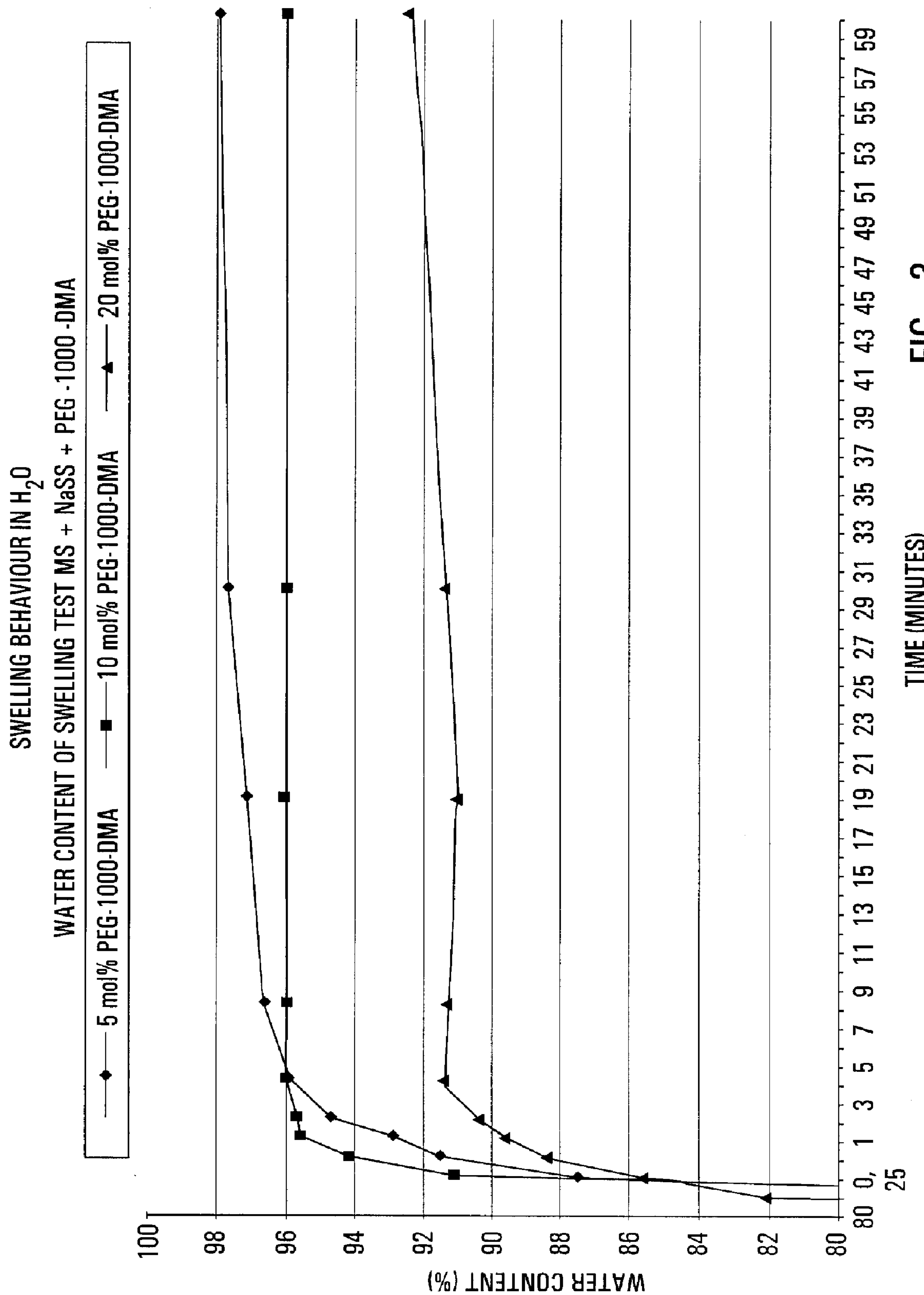
SWELLING BEHAVIOUR IN H_2O
WATER CONTENT OF SWELLING TEST MS + NaSS + PEG -1000 -DMA
5 mol% PEG-1000-DMA
10 mol% PEG-1000-DMA
20 mol% PEG-1000-DMA
WATER CONTENT (%)
100
98
96
94
92
90
88
86
84
82
80
80
0, 25
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
45
47
49
51
53
55
57
59
TIME (MINUTES)

FIG. 3

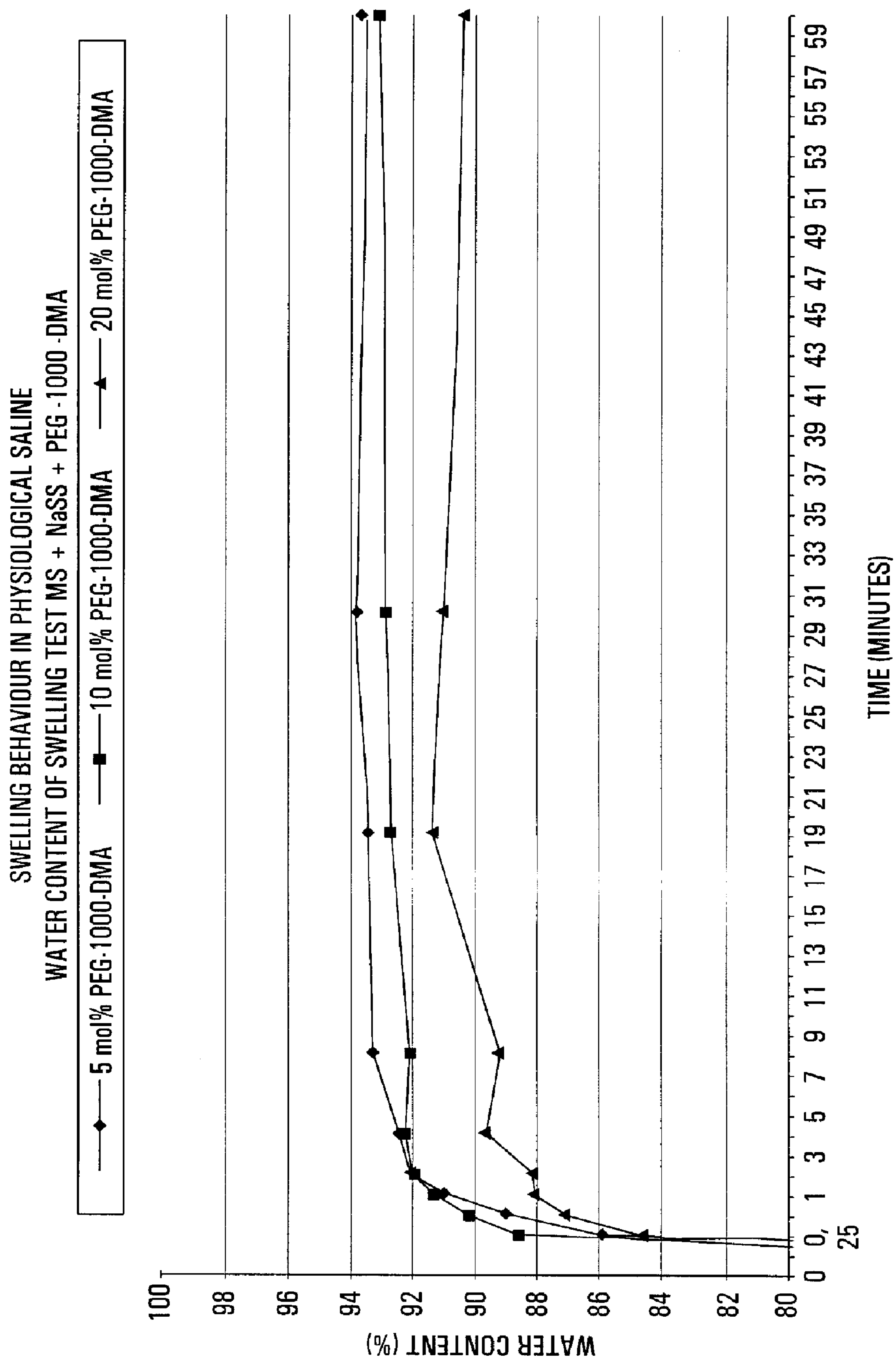
SWELLING BEHAVIOUR IN PHYSIOLOGICAL SALINE
WATER CONTENT OF SWELLING TEST MS + NaSS + PEG-1000-DMA
5 mol% PEG-1000-DMA
10 mol% PEG-1000-DMA
20 mol% PEG-1000-DMA
WATER CONTENT (%)
100
98
96
94
92
90
88
86
84
82
80
0
0,25
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
45
47
49
51
53
55
57
59
TIME (MINUTES)

FIG. 4